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Scope of project was changed March 20.

14. ABSTRACT

The purpose of this work was to articulate the state of the art in systems interoperability. It focused on (1) increasing the understanding of current and potential problems in Naval Computer Systems Interoperability; and (2) establishing a baseline for research activities that may impact these problems.

15. SUBJECT TERMS

Systems Interoperability

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ONR Final Technical Report

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Long term goals:
Our long term goals are to study the subject of Systems Interoperability in a general rather than a specific manner. Thus we are attempting to discover solutions to the generic issues in interoperability, starting with a method of characterizing the whole field. In the past, the problems have been discovered when systems fail or show strange behavior, we expect to determine ways to find the problem before the systems are put into operation.

In the work performed on this Award, we therefore hoped to rise above normal semantic problems, those normally first experienced in communication at the system interfaces and look inside systems to characterize problems due to "hidden processes". We hoped to use Navy examples to show the value of these methods in reducing or removing problems at early stages of the design or planning process.

Short Term Objectives:

The purpose of the original proposal was to plan a September 1999 workshop to establish the state of the art in semantics issues in systems interoperability. Due to a redirection of activities within the sponsoring office holding the conference became impractical. As a result, the project we redirected so that the PI would work with Bruce H. Barnes, the primary project consultant, to further the more general overall objectives of the study of systems interoperability.

The short-term objectives of the project therefore became the following:

(1) to produce a taxonomy of interoperability problems (i.e., those found when disparately designed and implemented systems are required to inter-operate);

(2) to transform the taxonomy into a set of characteristics that span the gamut of problems *from* differences in hardware and similar physical issues of the interoperable units or entities *to* policy and legal issues that can affect the interoperation when there are players in different legislative or other authorities, while looking at the attributes that affect the ease or difficulty of their correction; and

(3) to show that this characterization has value in Naval and other settings.

Approach during the time of the Award:
Interoperability involves the interfaces between systems previously expected to be separate from one another. Working with Edgar H. Sibly from George Mason University and Terry Bollinger from MITRE Corporation, we developed a taxonomy that focuses attention on the interplay among the organization's size and diversity, the different components of the computing systems, and various computational attributes of the system. We surmised that the problems caused by lack of interoperability can be characterized in several dimensions, since they span a very wide area of activities and levels of detail. We therefore represented interoperability problems in the form of a matrix with three dimensions: Diversity {[Unit, Force, Service, etc.] or [Department, Division, Company, etc.]}; Infrastructure [Physical, Platform, Data, Generic Support, Domain Support, and Application]; and Attributes [Generality, Uniformity, Frequency, Change Rate, Scalability, Binding Delay, Decoupling, etc.]).

We also considered the problems added by considering aspects of security, integrity, etc. and then looked at other more physical aspects of real systems (such as mechanical and electrical incompatibilities; e.g., the differences in frequencies of broadcast and voltages of equipment and supplies). Some real problems were used to test the applicability of this approach.

Finally we looked at a mechanism for assessing the "degree of interoperability" of a system [internal] or of two systems [external]. Sibley and Barnes have also worked with three graduate students to investigate the interplay between interoperability and security. While definitive results have not yet resulted, the approach has shown promise.

Publications Resulting from this Award:

1. The first was published as a MITRE tech report:
   "A Taxonomy for Military Systems Interoperability", by Bruce Barnes, Terry Bollinger, Edgar Sibley and Michael Morgan.
2. The second is currently titled:
   "A Taxonomy for Computer Systems Interoperability", By Bruce Barnes, Terry Bollinger, Edgar Sibley and Michael Morgan
   This paper has been submitted for publication in Crosstalk: The Journal of Defense Software Engineering.

A third paper in rough draft form at this time. It will be submitted within the year for publication in a nationally recognized journal. It is an extension of the other papers. It uses the taxonomy in an attempt to show the costs, tradeoffs, and risks in designing and

using systems that have not been specifically designed to be interoperable. Barnes, Bollinger and Sibley are collaborating on this paper.

Other Results:
1. Visited the UK and briefed the taxonomy at a Policy Workshop in Bristol in October 1999 as well as discussing it with representatives of the British Ministry of Defense.

2. Drafted and are continuing to work on a paper discussing findings and their applicability to systems interoperability in general. The first paper described the taxonomy and showed how it is generally applicable in many situations, including work discussed by one of the authors then located in ONR-Europe (Michael Morgan), showing the process of joint or combined operations, involving agreements with other countries, described in the taxonomy.

3. Barnes presented a summary of the results at the Working Meeting of the Interoperability Clearinghouse in April 2000.

4. Barnes attended the DIMACS Workshop on Interoperability in December 2000 where he presented the work.

Impact/Applications:
Our research so far has uncovered several places where applications of the taxonomy can disclose possible risks in interoperable systems. New efforts have already suggested that the Taxonomy and Matrix can be used in defining an "Interoperability Factor" predicting problems in the interoperation of the system or a set of systems -- thus estimating risk when systems need to interoperate or allowing trade-offs in their design in order to be more or less effective when inter-operating. The taxonomy appears to a research agenda, with an IT student expecting to pursue further work on this concept for his PhD thesis.

Transitions:
We are only just starting to develop and prove the methodology, having briefed it in October 1999 for the first time.

Related Projects:
The MITRE Corporation were funded by ONR for work on interoperability during this time. We used some of the material that they collected and worked closely with some of their team in developing and proving the taxonomy.

Publications:
Preliminary results were briefed at the Policy Workshop in Bristol (November 15-17, 1999). This presentation was well received. Reports of this and other UK visit were submitted to ONR in December 1999. Rough Drafts of the papers are now available as needed.

Patents:
None